How long does it take to get a highly educated labor force?

By Annababette Wils

1 The long time perspective on education.

One of the important elements of the population-development-environment (PDE) studies at IIASA is the long time horizon. Each of the case studies includes an historical analysis of the country – usually going back 30-40 years, but sometimes more than a thousand! -- We have used the simulation models make scenarios 30-100 years into the future. Time horizons of this length are common to demographic analysis – population projections typically range from 30-50 years. It is however, a much longer horizon that that of most social scientists.

This long time perspective eventually gets you seeing everything as a dynamic process, changing over time, happening over time, because when you are spanning decades, it usually becomes apparent that everything changes, evolves. That is why, when we look at education as one of the important links between population and development, we tend to ask how it will change over time.

2 What type of education do we mean?

Education can be taken to mean different skills. Australian aboriginal and Botswana San families have enormous skills acquired through traditional education, which allow them to survive in the desert where a Westerner would perish within a day or two. If Australian aboriginal or San children go to school, where they learn to read, write, do math, and recite history, they will probably not obtain full range of desert survival skills their elders had. Jared (1999), in a recent award-winning book on human history, remarks on the loss of knowledge – names, functions of trees and animals, local geography and such – that parallels the increase of modern skills such as reading, writing and using a computer.

When we speak of the skills that are necessary to economic development, it is clear however, that we are speaking of modern skills, which are almost always imparted in schools. This school education is the link between population and development that we are looking at in this paper.

3 The impact of education on development and environment

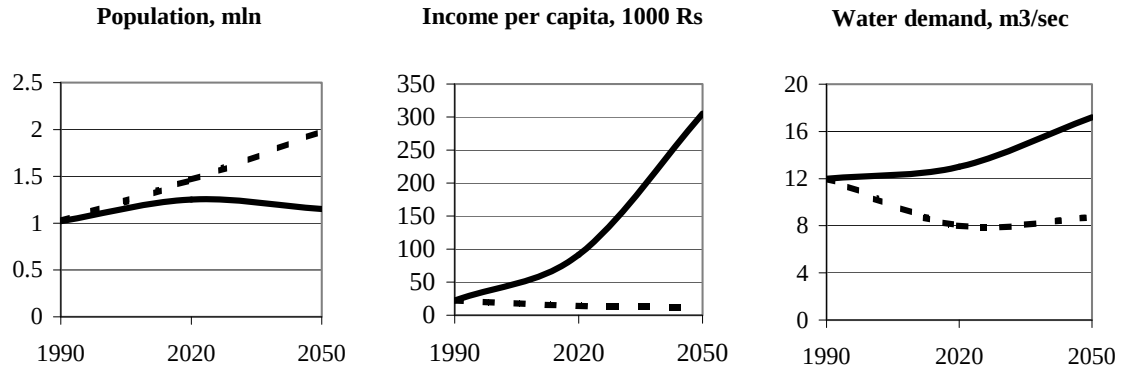
It is well recognized by economists that human capital – the number of people, but in particular, their education and skills – are an essential ingredient to economic development. Adult education is one of the most important predictors of economic wealth. Social scientists also view education as an essential ingredient to social changes

such as empowerment on childbearing (usually leading to fewer children), greater gender equality, active participation in a democracy, and other. As such, high human capital is a very highly desired good. To the extent that some nations or groups of people have low levels of this good, we would like to know how they can obtain more of it. And we would like to know: how long will it take to get it?

In our PDE studies, we have found that the effect of education on the environment is ambivalent. On the one hand, adults with more education have fewer children, thus reducing population growth. All else being equal (such as wealth, geography, social organization) fewer people use fewer resources and produce less pollution. On the other hand, the greater economic wealth that is generally linked with higher education increases consumption and therefore people's environmental impact. There is also the observation that the relation of GDP per capital and pollution is generally an inverted U-shape – that is as an economy begins to industrialize pollution increases, then, at higher levels of GDP per capita services, which pollute less, become an ever larger portion of the economy. Thus, the local impact of wealth can be ambivalent. However, there is no question that more wealth leads to increased consumption even if it is of industrial goods that are produced in another part of the world. Globally, then the impact of more wealth is mostly towards more resource use.

We see the dual impact of education clearly in the case of the scenarios we made with the PDE model for Mauritius. With regards to education there are basically two assumptions: one, education reduces fertility, second, education increases labor productivity. I will show you the results of two scenarios, called *Traditional*, referring to lower education achievements, higher fertility, and lower female labor force participation, and *Boom*, referring to high school enrollment, low fertility, and economic growth thanks to a productive labor force.

Figure 1. Population, income per capita, and water demand in Mauritius scenarios 1990-2050. Source: scenarios made for Prinz and Wils, 1994.



In the *Traditional* scenario, population grows from just over 1 million in 1990 to 1.8 million in 2050, while in the *Boom* scenario there are only 1.1 million people by that year. The fewer people however, are significantly better educated, as a result, the country attracts much foreign investment, and income increases almost 14-fold to the 1990 level

of Switzerland in 60 years. The combined results of population and income lead to higher water demand in the *Boom* scenario, to a significant extent because of greater household and tourism consumption of water.

4 The distribution of education

School attainment extremely unevenly distributed in the world. People in industrialized countries – including newly emerging industrial nations -- have on average a much higher level of education than people in developing countries do. In industrialized countries, almost all adults have complete primary and most adults 15-39 have secondary education (UNESCO, Statistical Yearbook, 2001?). In many developing countries, there are huge groups of adults who cannot even read and write, and minute portions with higher levels of education. See Figure 2. Within countries, there are also great inequalities. In particular, rural areas are usually much less educated than urban ones, and women less than men.

Figure 2. Adult education by age in Sweden, 1995 and Burundi, 1990 by four education groups: no school, primary only, secondary, and post-secondary. (in c:education/EducAchievbyAgeCountries). Source: UNESCO Statistical Yearbook, 1995.

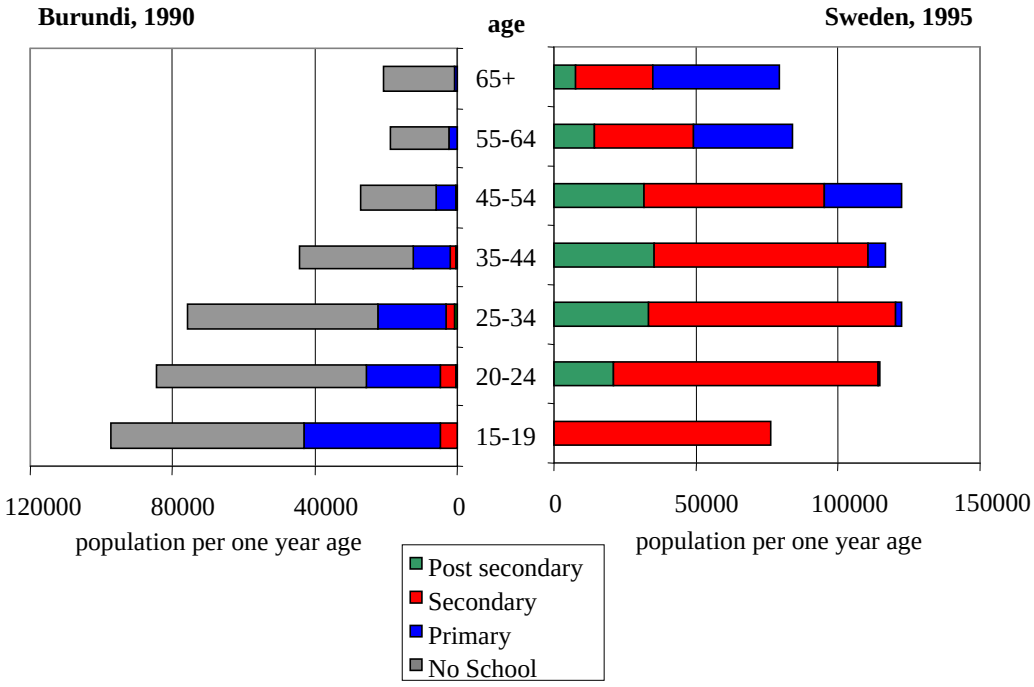


Table 1. Proportion of population without schooling in urban and rural areas in five selected countries. Source: UNESCO Statistical Yearbook, 1995.

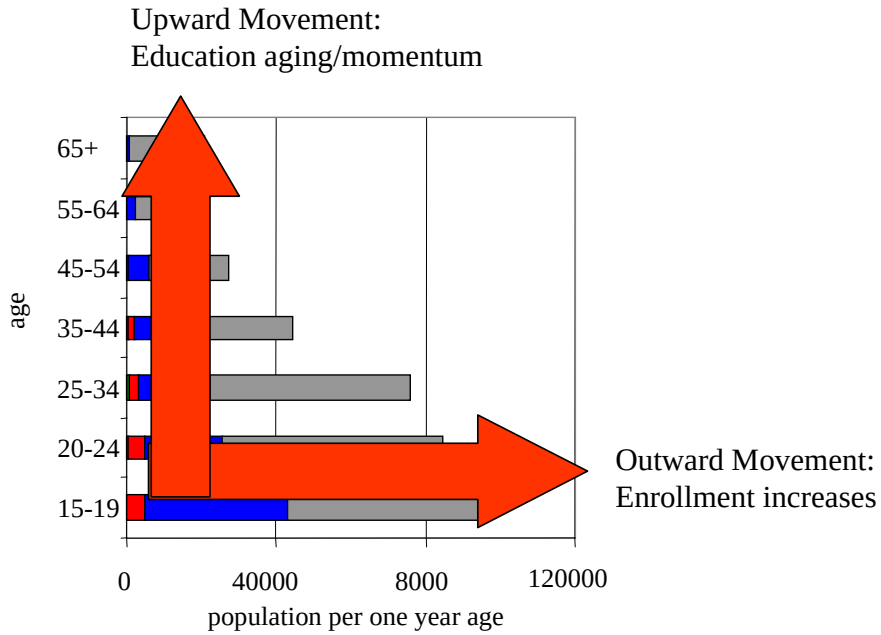
	Urban without schooling	Rural without schooling
Egypt, 1986, age 25+	48	78

Zambia, 1993, age 14+	9	27
Venezuela, 1990, age 25+	17	45
Nepal, 1991, age 6+	45	72
Turkey, 1993, age 6+	17	28

5 How does human capital increase?

How can a country like Burundi achieve an education profile like that of Sweden? Two things need to happen, an increase in school enrollment among children and young adults – moving out to reach all of a particular cohort --, and aging of higher education achievements through the age pyramind – an upward movement. The two dynamics are captured schematically in Figure 3.

Figure 3. Schematic representation of two dynamics which are necessary to increase human capital in the adult population.



First, education needs to reach outward to school-age children through enrollment in primary and secondary schools. In Burundi in 1990, a little over half of the population did not go to school, reflected in the large grey area of the bar for 15-19 year olds. An increase of enrollment would gradually move first the blue area of primary school attendance outwards, followed by the red secondary area, and later, post-secondary education. The speed with which this reaching out of education occurs might appear to be purely a factor of political will: governments who want to increase education need to invest more in schools. While financial and political resources are essential, our analysis below shows that even under the best of circumstances, education does not jump it

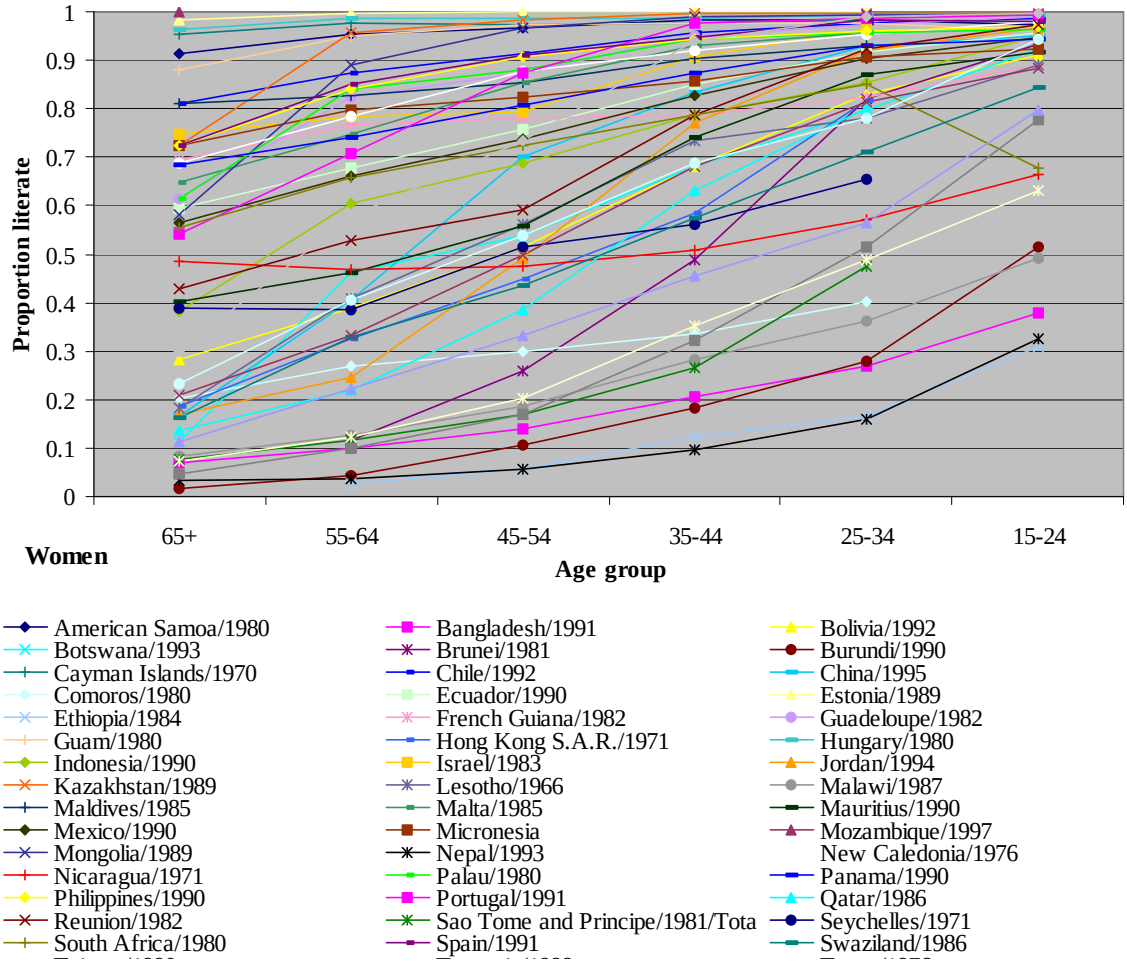
(Schumacher, 1973), it evolves slowly and with surprising regularity throughout the globe.

Second, more highly educated young cohorts need to gradually replace the less educated older cohorts through the process of aging. In Sweden, secondary education has been almost universal for some time – of the age groups under 34 in 1995, more than 95 percent attended secondary school. This means that almost all children started secondary school from 1973 on. Yet, among the older generation, there are still sizable proportions who have only primary education. It will take until 2020 for almost all adults under 65 to have attended school beyond the first level. The aging process is, of course, not subject to any policy, it is simply a matter of time passing, of demographic momentum. As such, all nations have to live with their historical school attendance legacy for a long time.

6 Time needed for outward increase of education: more school enrollment.

The US Census International Database (available online from www.census.gov) contains literacy by age for a large number of countries. Most of the data pertain to censuses in the 1990s and late 1980s. These data provide an important clue to how quickly education can move outward. Within each country, the increase of school enrollment over time is reflected in higher literacy rates among successively younger cohorts. In some countries, there are impressive gains, as shown for women in Figure 4. China for example, increased literacy from 17 percent among those 65+ in 1995 (the school entry generation from 1935 and before) to 95 percent among the 15-24 year olds. In other countries, the gain is much slower. In Bangladesh, 1991, 7 percent of those 65 and over were literate, and 38 percent of those 15-24, one of the slowest gains recorded in the data set.

Figure 4. Literacy by age group in 51 countries. Made with data from US Census International Database (available online at www.census.gov).

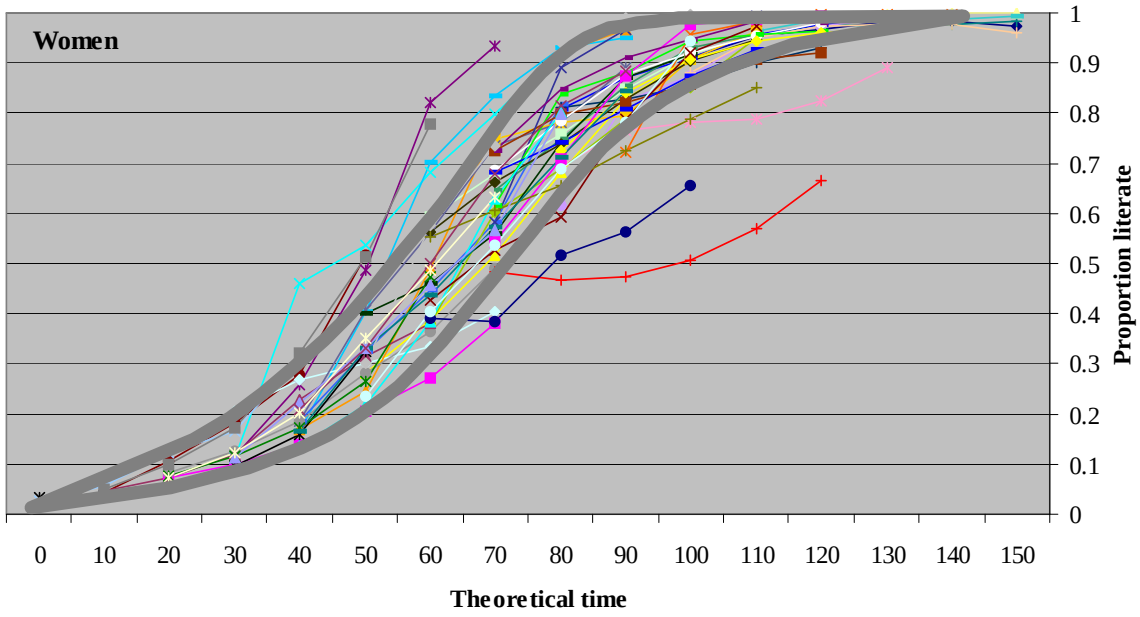


The figure shows that at very low levels of literacy, the gains from one 10-year cohort to the next are small. At very high levels of literacy, the increases are also small, while in the middle ranges there are larger gains from one cohort to the next. As a jump of thought we ask: Is there perhaps a general sigmoid pattern of literacy increases over time, and are the country specific lines segments along this pattern? If such a pattern exists, it would tell us something about the range of time between a fully illiterate cohort, and a literate one.

To answer the question, in Figure 5, we arrange each country's line along an x-axis of theoretical time and in such a way that all the lines together make as close to one general pattern as possible. The results show that in fact, most countries' lines fall within a sigmoid band of literacy increases that spans 80-110 theoretical years from 5 percent or less of the cohort literate to 95 percent or more literate. What this means is that, following this general, and globally observed pattern, it takes 80-110 years of gradual school enrollment and education increases to reach nearly complete literacy, or 4-5 generations. There are some notable exceptions, which show that a "fast track" is possible. The left-hand outliers on the graph are four countries with slightly faster

literacy increases (8 percent of the sample): Botswana, Tanzania, Brunei, and China. These countries suggest that there might be only 60-70 years between a nearly illiterate and an almost fully literate cohort. Three countries from our PDE case studies that are included in this data set – Mauritius, Mexico, and Mozambique -- lie within the general pattern.

Figure 5. Literacy by age line segments of 51 countries lined up to create a general sigmoid pattern of cohort specific literacy increase. Made with data from Figure 4.



In other words, even following fastest historically observed increases, it takes about 3 generations for literacy to move out and reach all of the people in a particular cohort. This is somewhat sobering. On the positive side, of the 21 countries for which we had data from the 1990s, the lowest level of literacy observed among young women 15-24 years old was 32 percent in Nepal, 1993, which is 30-70 years away from a fully literate cohort along the general pattern. In fact, in all but only five of these 21 countries[1], more than 80 percent of the young women were literate.

We also have some information about how long it takes before a cohort achieve full complete primary education and full complete secondary education (starting from a cohort in which only a very low percentage achieve this), and on how education reaches out within a country.

Educational achievement by level – no schooling, primary, secondary, post-secondary – and age can be used to obtain the same historical perspective as above for literacy. Data for selected countries can be found in the UNESCO Statistical Yearbooks. We took the 1990s data from 22 countries around the world[2], and arranged it on a graph along

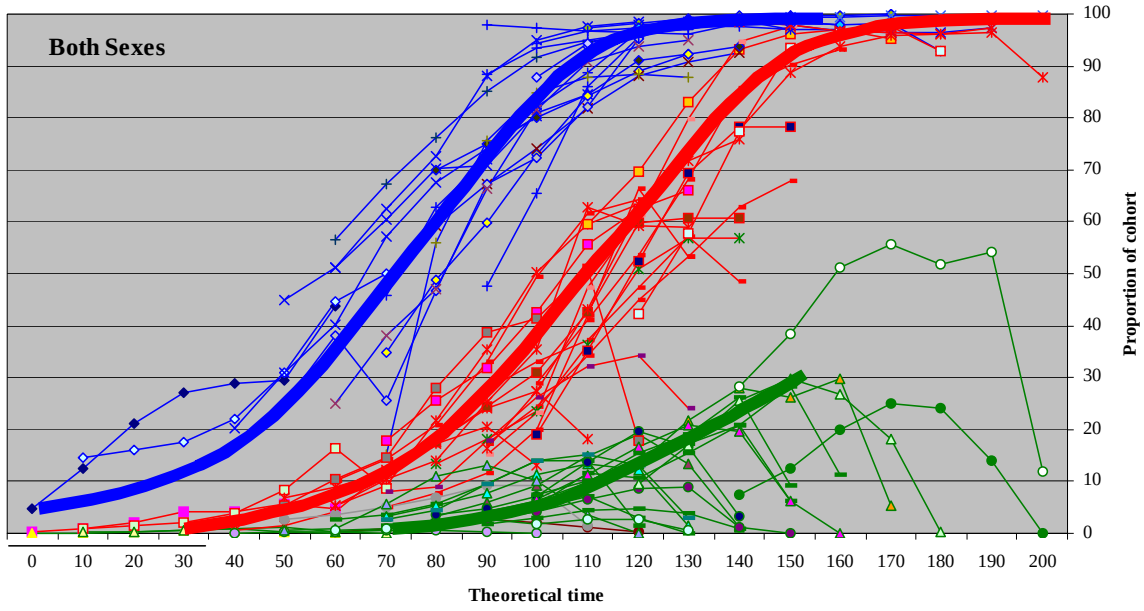
[1] Bangladesh, Burundi, Mozambique, Nepal, and Uganda.

[2] The countries are: Burundi 1990, Mauritius 1990,Namibia 1991, Sudan 1993, Uganda 1991, Zimbabwe 1992, Canada 1991, El Salvador 1992, Mexico 1990, Panama 1990, United States 1994, Argentina 1991,

theoretical time similarly to Figure 5 above. The difference is that each country now has a set of three lines: age specific proportions who have attended primary, secondary, and post-secondary school. These sets are shifted *together* along the theoretical time axis to make one general pattern – where possible (a similar experiment can be found for 1960-90 school enrollment in Wils and Goujon, 1998).

The result is shown in Figure 6. The blue lines are primary, red is secondary, and green is tertiary. Again, a rough general pattern appears, of the same shape as for literacy. As with literacy, the time between a cohort which has attended no primary to a cohort almost all of whom have at least some primary education is about 100 years. Secondary education follows along a similar slope, with a delay that is 30-50 years. Tertiary education increases much more slowly than the other levels. The highest levels are found in industrialized countries, and the highest level by far in the United States.

Figure 6. School achievement by primary, secondary, and tertiary levels in 22 countries arranged by country along theoretical time to create a general pattern. Data from the UNESCO Statistical Yearbook, 1996.



It is impossible to tell what the future of tertiary education in industrialized countries might be. On the one hand, the in the United States, cohorts from age 25-34 to 45-54 all have a little more than 50 percent post-secondary education. This indicates a stabilization at least in the United States at this fairly high level. On the other hand, Norway, which achieved general secondary education far before any of the other 22 countries (in Norway 98 percent of those over 65 have secondary school), has much lower levels of post-secondary school attainment, merely a quarter of those aged 25-34 and 35-44.

Bolivia 1992, Ecuador 1990, Venezuela 1990, Bahrain 1991, China 1990, Hong Kong 1991, Bulgaria 1992, Ireland 1991, Sweden 1995, Norway 1990. The age groups are 15-19, 20-24, 25-34, 35-44, 45-54, 55-64, 65+.

Leaving tertiary education and its future as an unknown, one could venture that the outward education shift from a cohort which receives practically no education, to one with universal secondary, and high levels of tertiary as observed in the United States, Norway, Canada, and Sweden in this figure takes on the order of one and a half centuries. This would leave countries – many of them in sub-Saharan Africa --, which are in the beginning of this shift at a disadvantage that they cannot hope to eliminate for 3-4 generations – even assuming that education in the industrialized countries remains stagnant.

Did it take the presently industrialized countries as long to get to their present levels of education? Evidence from three European countries indicates that the historical shift in that region may have taken even longer than 150 years. Mitchell's (1994) *International Historical Statistics Europe 1750-1988* has the number of pupils in primary and secondary school, and the populations by 5 year age groups from about 1850 onwards. While this is not enough to obtain exact enrollment rates in primary and secondary school, we can get approximations. The population of primary school age is assumed to be 6-11 years old, and the size of that population is estimated as $0.8*(POP_{age\ 5-9})+0.4*(POP_{age\ 10-14})$. A similar procedure applies for the 12-17 year old population of secondary school age.

According to these approximations, the gross enrollment ratio in Austria around 1850 was already .66, in Belgium it was .94 and in France it was .85. By 1900 enrollment in primary school looks like it was complete or close to it in all three countries. Secondary education did not rise until much later, mostly in this century. This very cursory data would indicate that at least in these three countries, education began more than 150 years ago, and that the onset of secondary education occurred more than 50 years after primary: education increase in these three countries was *slower* than what we see in Figure 6.

Table 2. Estimated gross primary and secondary enrollment in Austria, Belgium and France around 1850 and around 1900. Calculated with data from Mitchell (1994).

	Around 1850		Around 1900	
	Estimated Primary GER	Estimated Secondary GER	Estimated Primary GER	Estimated Secondary GER
Austria	0.66	0.02	1.09	0.03
Belgium	0.94	0.02	0.98	0.04
France	0.85	0.01	1.43	0.03

7 Geographical diffusion of school enrollment.

Another consideration in the spread of education is how it reaches out to different geographical regions within a country. Like many social changes, it is likely that education begins in the urban capital and gradually spreads out to reach more remote

areas. In Mozambique, where detailed data on educational achievements were made available to the PDE study there, this pattern of diffusion is exactly what we observe. As it is the only country for which we looked at the data in this way, we present results for Mozambique only.

The capital of Mozambique is Maputo City, located in the southern tip of a large country that is almost 1000 kilometers long from north to south with very poor north-south connections. All education indicators, namely gross and net enrollment at primary, secondary, and tertiary levels, and educational achievement of adults uniformly show the same patterns:

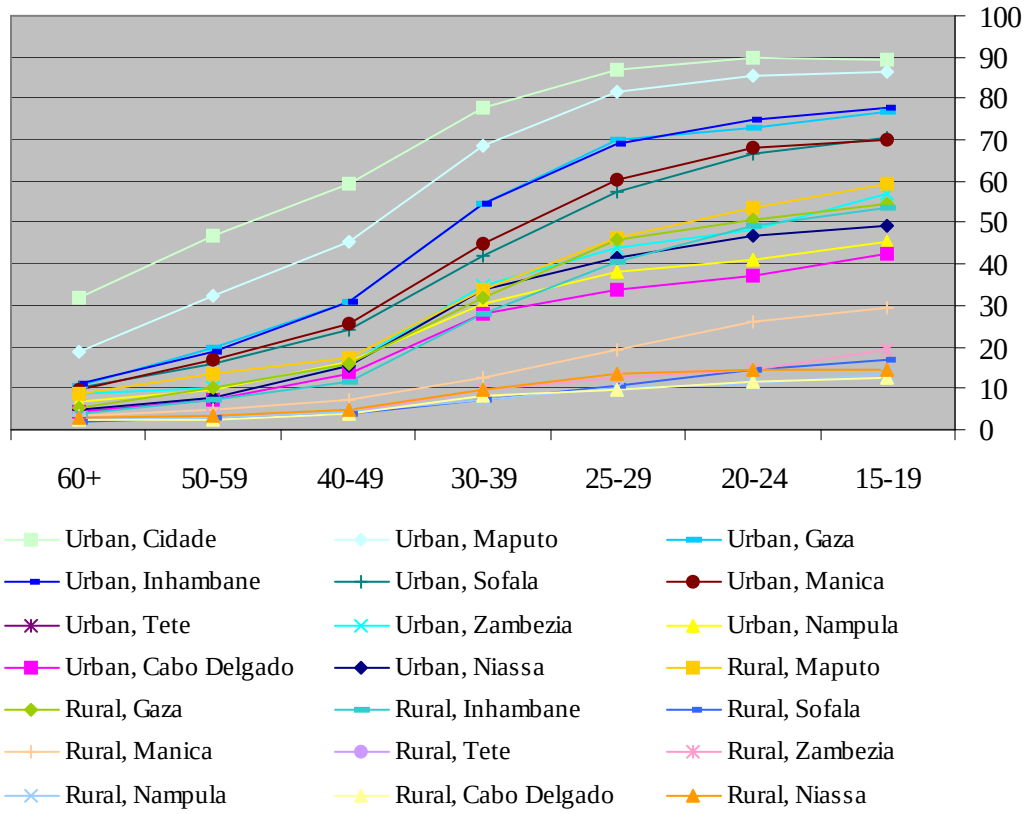
Education is highest in the capitol, and lower, the further north the province.

Within provinces, education is highest for urban males, followed by urban females, then rural males and last, rural females.

The *differences* between rural/urban and gender within provinces are significantly larger in the northern and central provinces than in the south. In the southern provinces Gaza, Inhambane and Maputo, there are only very small differentials between the rural and urban, male and female education.

Figure 7 shows literacy for women age 15+ in Mozambique, by age group, province and urban rural residence. The highest literacy rates by a clear margin are in the capitol, Maputo City. The next highest rates are in the urban areas of the three provinces closest to Maputo City, Maputo Province, Gaza, and Inhambane, followed by Manica and Sofala, which are next in distance from Maputo City. Below these top six lines is a group, which consists of the rural areas of the three southern-most provinces and the urban areas of the five northern provinces. At the bottom of the graph are the rural areas for the more remote provinces, with Cabo Delgado, located along the northern border, at the very bottom. The figure for men shows higher literacy rates for men in all areas, and a very similar ranking of literacy – although among men, urban literacy rates are higher than all rural rates, whereas among women, southern rural women have higher literacy rates than some remote northern urban areas.

Figure 7. Age-pattern of literacy for women in Mozambique, by province, urban and rural area according to the 1997 Census. Source: INE (2000).



A pattern of what we can call *sequential enrollment diffusion* would explain all of these observations. According to the hypothesized pattern, school enrollment would first expand in the capital city, among boys, followed by girls. In the next stage, school enrollment diffuses to the urban areas, reaching those closest to the capital first, and again benefiting boys before girls. In the third stage, enrollment expands into the rural areas, first to boys then to girls. At the end of the third stage, there is high enrollment in urban and rural areas among both sexes. There is inequality in education achievement until all stages are completed, and because of the sigmoid shape of education increases, the inequality is greatest in the middle of the diffusion process. The extent of the inequality will depend on how much time there is between the initiation of each stage.

Like countries in section 6, the separate lines of education increases all group together to form one general pattern of education increases in Mozambique. The pattern is neater than for the mix of countries in Figure 4, and the time between an illiterate and an almost fully literate cohort is as found above – about 100 years.

8 Time needed for upward increase of education: aging through the population pyramid.

The outward movement of education in the form of higher enrollment and school achievement subsequently moves upward through the age pyramid, as better educated cohorts age. This process too, takes time, and is no less important, for it is adults, not

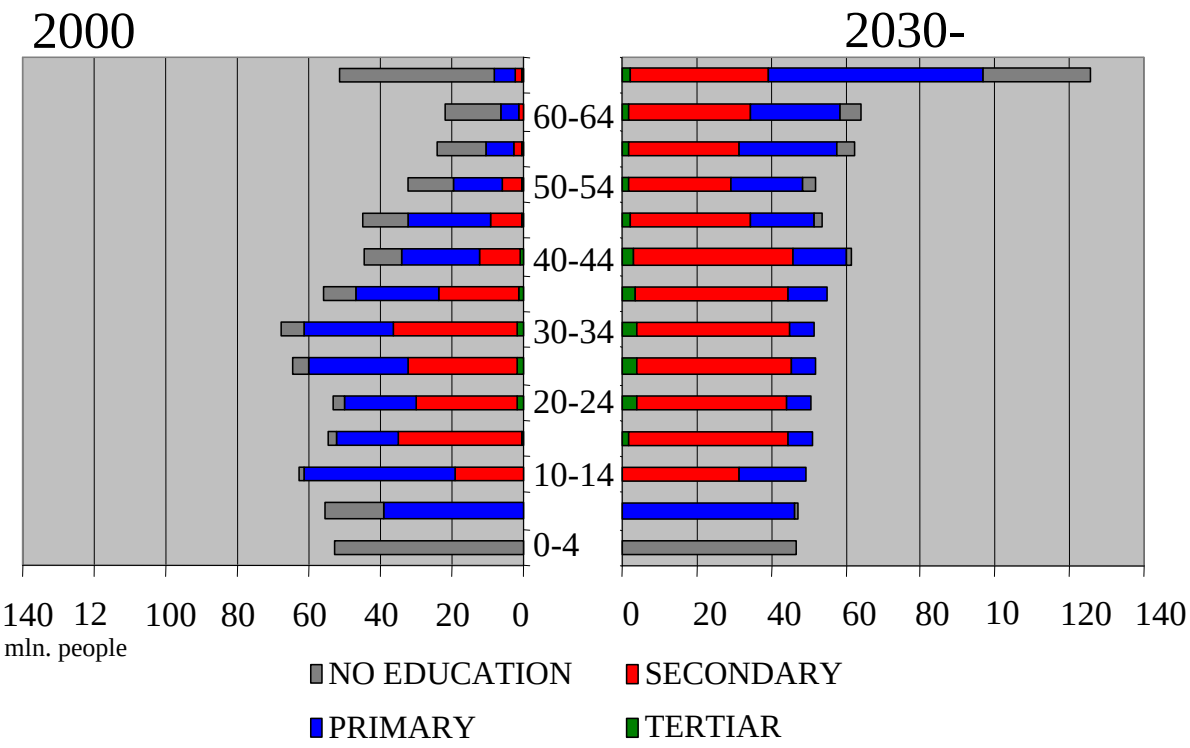
school-age children and teenagers, who make decisions and use skills that affect economic growth, consumption, resource use, and social processes ranging from family building to active political participation.

In some ways, the aging process is simple: it proceeds in a regular fashion, one year at a time. So we can state that the education achievement of a cohort of say, 20 year olds today, will be about equal to that of 70 year olds 50 years from now (barring significant mortality and migration differentials). Or, we can say that is enrollment remains constant for 50 years, then 50 years from now, the education achievement of all people of working age 15-65 will exactly reflect those patterns.

However, as Lutz and Goujon (2001) argue, only a genuinely demographic approach, with age cohorts, and multiple states reflecting educational achievements, can adequately capture the changing future education profile of a region. In part, this is because education feeds back into the process of population reproduction – as women with more education tend to have fewer children. In part, it is because enrollment itself changes over time – as we saw clearly above – parallel to the aging process and the multi-state cohort component approach is able to manage both types of changes simultaneously.

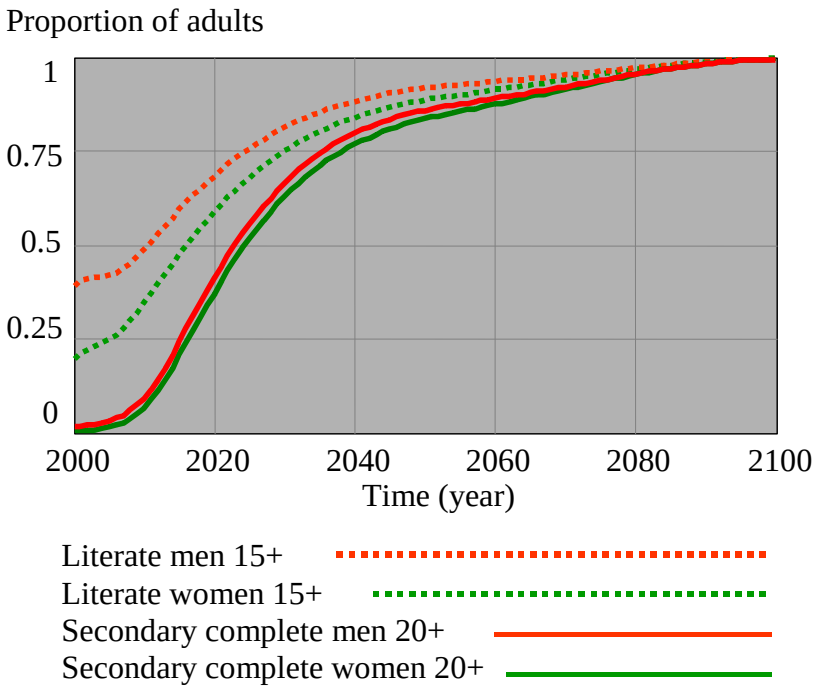
Figure 8 illustrates the aging process with two half population age pyramids with education for China, taken from Lutz and Goujon, 2001. The left half shows education and age structure in 2000, the right in 2030, assuming constant school enrollment and transition patterns. By 2030, the education achievements of almost all adults are similar to those of the young adults age 20-24 in 2000. Also, the poorer education profile of older cohorts in 2000 has mostly aged out of the working ages in the pyramid.

Figure 8. Education pyramids for China 2000 and 2030 with constant school enrollment and transition patterns. Source: Lutz and Goujon, 2001.



In terms of this paper's main question, how long it takes to get a highly educated labor force, it is useful to separate the upward aging process from outward enrollment increases. For Mozambique, a country with presently one of the lowest levels of literacy and secondary school attainment among adults over 15, we ran a multi-state scenario, which assumed instant complete school attendance for all cohorts entering and secondary school completion for all cohorts in school and entering school after 2000. Scenario results in Figure 9 show the proportions of men and women over 15 who are literate, and the proportion of men and women over 20 with complete secondary education from 2000-2100.

Figure 9. Proportion of men and women over 15 who had grade 4 or higher (to achieve literacy according to the UNESCO definition) and men and women age 20 and higher with complete secondary education in Mozambique, if from 2000 onwards, there was complete school intake and all children who entered school finished secondary. Source: Own calculations with multi-state PDE-Mozambique model.



It takes as long as a human life for a change in enrollment to age through the whole pyramid. In 2000, in Mozambique, 39 percent of the men and 20 percent of women were literate according to the UNESCO definition that they finished fourth grade[3] and the proportions with complete secondary school were 2 and .5 respectively for men and women. The scenario takes a few years to take effect because of the time needed to finish school. Then, both literacy and secondary school rise quickly, as large, young cohorts move into the age groups over 15 and over 20. The expansion tapers off, because by 2050, only older adults still have the low education achievements from pre-2000 enrollment levels, and these age groups are smaller because of mortality and population growth[4].

References

Barro, Robert J., Lee, Jong-Wha,"International Data on Educational Attainment Updates and Implications," August 2000. available in pdf format from http://post.economics.harvard.edu/faculty/barro/workpapers.html

[3] The national figures for literacy, which apply a lower standard, are higher.

[4] Population growth in this scenario is low because it incorporates HIV/AIDS.